https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

Nitrate Concentration (NO3-) in Groundwater of the Urban Area of Nova Mamoré - Rondônia in the Brazil / Bolivia Border

Vitor Arika Uesugui Costa[1], Carlos Alberto Paraguassú-Chaves[2], Luciana Rezende Alves de Oliveira[3], Edilson Carlos Caritá[4], Charlles da Silva Barata[5], Fabrício Moraes de Almeida[6], Lenita Rodrigues Moreira Dantas[7], Izan Fabrício Neves Calderaro[8] and Leonardo Severo da Luz Neto[9]

[1]Master in Environmental Technology from the University of Ribeirão Preto – UNAERP, São Paulo, Brazil. Professor of Federal Institute of Education of Rondônia

[2]PhD in Health Sciences - University of Brasília - UnB, Brazil; PhD in Science - University of Havana (Cuba); Post-Doctor in Health Sciences - UnB and Degli Studi D'Aquila University - IT. Professor at the Federal University of Rondônia - Brazil. E-mail: carlos.paraguassu@gmail.com

[3]PhD in Chemistry from FFCLRP - University of São Paulo/USP; Full Professor and Coordinator of the Masters and Doctoral Program in Environmental Technology of the University of Ribeirão Preto – UNAERP, São Paulo, Brazil.

[4]Doctor of Medical Sciences (Biomedical Research) from the University of São Paulo; Full Professor at the University of Ribeirão Preto - UNAERP; Professor of the Master's and Doctoral Program in Environmental Technology of the University of Ribeirão Preto – UNAERP, São Paulo, Brazil.

[5]Master in Geography - Federal University of Rondônia. Researcher at the Higher Institute of Health Sciences and Environment of the Amazon – AICSA

[6]PhD in Physics (UFC), with post-doctorate in Scientific Regional Development (DCR/CNPq). Researcher of the Doctoral and Master Program in Regional Development and Environment (PGDRA/UNIR). Leader of line 2 — Technological and Systemic Development, and Researcher of GEITEC — Federal University of Rondonia, Brazil. E-mail: dr.fabriciomoraes001@gmail.com

[7]Specialist geographer and lawyer. Researcher of the Group of Socioenvironmental Studies and Research and Public Policies - GEPCAP. E-mail: lenita_dantas@gmail.com

[8]Master in Regional Development and Environment (PGDRA/UFRO). TI Analyst of Federal University of Rondônia Foundation, Porto Velho, Rondônia (Brazil). Member of GEITEC/UNIR/ CNPq. Brazil. E-mail: izancalderaro@gmail.com

[9]Master in Education - Autonomous University of Barcelona, Spain. Master in Psychology - University of São Paulo. Master in Religious Studies - Faculty of Theological Education Logos of São Paulo. Bachelor of Nusring. Professional Physical Education. Bachelor in Theology. Professor at the Federal University of Rondonia, Brazil - Department of Collective Health, Researcher at the GEITEC and GEISC of the Federal University of Rondonia, Brazil. Email: lluz@unir.br

Abstract**—** *Objective: To analyze the concentration of N nitrate (NO3 -) in the urban groundwater of Nova Mamoré on the Brazil / Bolivia border. Method: Data were collected from 40 water samples according to Standard Methods for the Examination for Water and Wasterwater along with the methodology proposed in the Water Sample Collection and Preservation Guide of the Environmental Sanitation Technology Company (CETESB). The sites were georeferenced using the Global Positioning System (GPS). For nitrate measurement, the spectrophotometry method was used, using Spectrophotometer, brand Micronal B495. The chemical reagents used were manufactured by Alfatecnoquímica and made available in two vials called reagents 1 and 2 (nitrate reagent). Results: The urban groundwater used by the population of Nova Mamoré for human consumption and other utilities is impacted by high levels of N nitrate (NO3-). Seventy - three percent (73%) of the sample presents levels> 10 mg/L of nitrate. These sites constitute urban areas of high environmental risk to human health, a public health issue. Only 17% presented levels <10 mg/L of nitrate. Only 7.5% of the samples are less than 3 mg/L of nitrate. Conclusions: The high concentration of nitrate in urban groundwater in cities in*

https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

the Brazilian Amazon puts at risk the health of a large part of the population that supplies this type of water resources for human consumption. It alerts itself to a public health issue.

Keywords— N Nitrate Concentration, Urban Groundwater, Environmental Risk for Human Health.

I. INTRODUCTION

Water for human consumption can be obtained either in surface water springs or underground springs. The underground spring is a resource widely used by a portion of the Brazilian population, mainly in the Amazonian cities. Groundwater can be collected in the confined or artesian aquifer, located between two relatively impermeable layers, which makes it difficult to contaminate. Groundwater collected in the unconfined or free aquifer, which is close to the surface, is more susceptible to contamination. According to Varnier and Hirata [1] due to the low cost and ease of drilling, free water abstraction, even though more vulnerable to contamination, is more frequently used in Brazil.

In Rondônia, in the Western Amazon, groundwater represents an important resource in human supply. Of the total water that the Water and Sewage Company of Rondônia (CAERD) produces, 35% originates from the underground source [2]. According to Campos [3], groundwater, because it is a low-cost alternative, is accessible to all, especially the low-income population, both in daily supplementation and in the total replacement of water provided by the public and private service.

Portaria No. 2,914 of the Ministry of Health of Brazil establishes that water for human consumption is drinking water intended for ingestion, food preparation and personal hygiene, regardless of its origin, and treated water, is water submitted to physical processes, chemical or a combination of these, in order to meet the drinking standard [4]. The potability standard is defined as the set of values allowed as a parameter of water quality intended for human consumption. The Health Legislation System relates to the physical, organoleptic and chemical characteristics of water; their maximum permissible values (MPV) and the microbiological and radioactive quality characteristics. Add to this relationship the minimum contact times to be observed for disinfection by chlorination, as a function of temperature and pH of the water; and the minimum numbers of samples and frequency for water quality control of the supply systems, for various purposes [5].

Brazilian legislation is exhaustive: "Water containing concentrations greater than 10 mg/L of nitrogen (N) in the form of nitrate (NO3-) is unfit for human consumption". Concentrations above 3 mg/L of nitrogen in the form of nitrate (NO3-) are indicative of contamination due to anthropogenic activities, also indicators of bacterial contamination and fertilizers. A safety alert for the health of people who are subjected to such a situation.

According to Campos and Rohlfs [6] nitrite and nitrate are found naturally in water and soil in low concentrations. The deposition of organic material in the soil increases drastically the amount of nitrogen. This nitrogen is biochemically transformed and finally becomes nitrate that has great mobility in the soil reaching the underground spring and depositing there. Melo Junior et al [7] point out that the contamination of urban groundwater by nitrate results from the inefficiency of basic sanitation services and the lack of sanitary sewage in the urban area. The inefficiency of these services forces the local population to build black and septic tanks for effluent disposal within the immediate vicinity of their land, which in practice, this process translates into contamination of groundwater.

According to Barbosa [8], nitrate occurs naturally in groundwater, but its presence in high concentrations is a result of human activities, mainly to the use of in situ sanitation systems the nitrogenous substances of the organic residues are oxidized by chemical and biological reactions and the result is the presence of nitrate in the soil. Nitrate is extremely soluble in water and can move easily and contaminate the aquifer at long range due to its persistence and mobility. It is observed the power of contamination present in this chemical agent, once present in the soil or directly in the water has very easy to contaminate the groundwater. For these authors nitrate (NO3-) is a colorless, neutral, strong, oxidizing and water soluble ion, corresponding to the final biological stabilization ratio of the organic nitrogenous matter.

For Foster; Ventura and Hirata [9] nitrate is the most common contaminant found in groundwater and its concentration rarely exceeds 5 mg/L in non-polluted waters and concentrations above 10 mg/L represent a strong indication of water contamination. In addition to the use of agricultural fertilizers and livestock, in situ sanitation systems, whether by septic tanks or rudimentary pits, are another important source of nitrate in groundwater. Due to the hazardous nature of this chemical agent, the lack of planning in the construction of each individual sanitation system (well x pit), allows the contact of the effluent from the well with the well water. Drinking water sources containing high concentrations of nitrate present a great risk to public and animal health [6]. Waters used for supply, contaminated with nitrate, have caused problems for both animals and man. Children under three months of age are more sensitive than adults because they consume more water compared to their body weight; and by the pH of their stomach is favorable to the development of bacteria that reduce nitrate to nitrite, which does not normally occur in adults [10].

https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

Nitrogen as nitrogen is the main form of nitrogen found in waters, and is the last stage of nitrogen oxidation, which originated in organic or inorganic nitrogen and underwent several transformations until reaching nitrate. Nitrate is harmful to health, even if it does not exceed the VMP set forth in Administrative Rule 2,914 of the Ministry of Health and requires the attention of the public health authorities and the supervisory agencies [5]. Where nitrate values exceed PMV, there should be continued monitoring of the amount of nitrate in the water, as well as monitoring of the specific health for this population, with special attention to the pathologies associated with excessive nitrate consumption, mainly in children which are more susceptible to diseases caused by nitrate in water [5].

In several studies by Paraguassú-Chaves et al [11]; [12] have already pointed to a safety alert for the health of people who are subjected to such situation in the majority of the cities of the Amazon with sanitation and sewage services precarious or practically nonexistent. That the population of these cities consume water with concentrations higher than 3 mg/L of nitrogen in the form of nitrate (NO3-) which in itself is indicative of contamination due to anthropogenic activities, also indicators of bacterial contamination and fertilizers.

Lima [13] had already considered that, in the presence of nitrate in the water, even in low concentrations, besides indicating that the contamination is old in the environment, it reveals the presence of organic matter associated with bacteria, viruses and parasites, alive or in some of the stages of decomposition. These agents cause various diseases, mainly acute diarrhea and, in the form of nitrate, is a carcinogenic indicator. The main constraints are as sources of contamination to the anthropic and multi-point action of the in situ sanitation system, type septic tank and black cesspits, exposure and precariousness of the wells, exposure of solid waste, sewage discharge of all nature. Thus nitrate (NO3-) contamination occurs in urban areas in the Amazon region and on the border with Bolivia [14]. Allied to all these conditions the flooding / flooding of the abundant water courses in the region are determinant to aggravate the contamination of the water table. The population is consuming water with a high degree of nitrate contamination. It alerts itself to a public health issue [14].

According to Barata [15] the municipality of Nova Mamoré lies between the parallels 09º 30 'S and 11º00' S, and Meridians 63º30'W and 65º30'W, located about 270 km southwest of the capital of Porto Velho, State of Rondônia. It has an area of the territorial unit of 10,071,643 km2, the population of the municipality of Nova Mamoré is 22,546 inhabitants, with a demographic density of 2.24 hab/km2 [16]. The water supply is in charge of the Water and Sewage Company of Rondônia, which has 10,280 meters of installed water distribution network serving 3,457 inhabitants [17]; [18]; [19]. Sanitary sewage is practically nonexistent in the municipality. Depletion is effected only by black or septic cesspits or irregularly in the streams that cut the urban area, a fact that compromises the quality of local water resources.

The basic sanitation, specifically, water supply and sewage collection of the municipality is coordinated by the Water and Sewage Company of Rondônia (CAERD). The number of households with access to the general network of treated water is still very low: only 16.88% of the households. While 83.91% are supplied by wells or spring on the property, only 4.84 are located outside the property. The proportion of households with adequate sanitation was only 1.13%, well below the state proportion (11.62%), while 49.08% was semi-adequate and 49.79% inadequate. Indicating, therefore, that the basic sanitation of the municipality is still very precarious.

In the municipality of Nova Mamoré, there is no sewage collection system according to the EBITDA data from January to December of the year 2014 [19].

Deficiency in basic sanitation can lead to public health problems, as water pollution can generate diseases such as: basilar dysentery, dengue fever, yellow fever, leptospirosis, hepatitis A, and others. The lack of basic sanitation in the municipality becomes even more aggravating due to the fact that the vast majority of households in the municipality are supplied by wells or spring without due environmental concern. Therefore, the local culture of basically using the open wells in their properties for human consumption is extremely dangerous, requiring more in-depth studies as an evaluation of the socio-environmental impacts resulting from this practice on human health [15]. Another implication of the lack of sanitation is environmental damage, such as flooding, silting of watercourses (due to deforestation and occupation of the banks), disappearance of green areas, collapse of slopes, garbage and sewage channels [15]. In Nova Mamoré, there are no storm drainage systems in the city.

The objective of this study was to analyze the concentration of N nitrate (NO3-) in the urban groundwater of Nova Mamoré on the Brazil / Bolivia border and to verify the degree of contamination of the water consumed by a large part of the population of this Amazonian city.

II. METHOD

Data and water samples were collected according to the Standard Methods for the Examination for Water and Wasterwater (APHA) [20] along with the methodology proposed in the Water Sample Collection and

https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

Preservation Guide of the Sanitation Technology Company Environmental - CETESB [21]. Wells and water collection points were registered and some important variables such as collection date and time, well age, depth, hygiene conditions, cesspools, nearby sewage, presence of animals, rainfall in the last 24 hours .

The sites were georeferenced using the Global Positioning System (GPS). For nitrate measurement, the spectrophotometry method was used using the Spectrophotometer, brand Micronal B495, the chemical reagents used were made by Alfatecnoquímica and available in two vials called reagents 1 and 2 (nitrate reagent). The analyzes were carried out in laboratories of private higher education institution as well as private laboratory.

The points of water collection for analysis were given in the urban area of Nova Mamoré, Rondônia, on the border with Bolivia. 40 samples were taken. The owners or real estate agents, in the sites of the selected wells, were registered and signed the Term of Free and Informed Consent - TCLE.

III. RESULTS AND DISCUSSION

The collection of 40 samples of groundwater occurred in two stages in urban locations of Nova Mamoré. The first stage of the random sampling, stratified in the urban area of Nova Mamoré, was selected 20 cacimba or Amazonian wells, located in the districts Centro, São José, Santa Luzia, Nossa Senhora de Fatima and Chacareiro. The second stage was the sampling in 20 cacimba or Amazonian wells, located in the districts Planalto, Novo Horizonte, João Francisco Clímaco and Cidade Nova.

First Sample Group. In the sample survey of the districts of Centro, São José, Santa Luzia, Nossa Senhora de Fatima and Chacareiro, 100% of the samples were detected high levels of N nitrate (NO3-), above 10 mg/L, characterizing a large area of the population of the city of Nova Mamoré that consumes water taken from these wells of residential (residential) and commercial supply.

As shown in Table 1, high levels of N nitrate (NO3-) were detected in 100% of the samples. Being that> 10 mg/L were detected in 100% of the wells and collection points. All 5 neighborhoods have their groundwater with a high degree of N nitrate contamination (NO3-), that is, water that is unfit for human consumption.

In the Centro district, the levels of N nitrate (NO3-) are extreme. The seven (7) sampling points range from 42,298 mg/L to the highest value and 12,123 mg/L the lowest value, with a mean of> 27 mg/L. The APs (sample points) 1, 2, 3, 4 and 5 respectively present the levels of 42,298 mg/L, 41,335 mg/L, 35,145 mg/L, 24,011 mg/L and 23,086 mg/L respectively. The lowest levels were found in AP5, 16,441 mg/L and AP7 12,123 mg/L.

In the São José neighborhood, the levels of N nitrate (NO3-) present a high risk for human health. 100% are higher than 10 mg/L, with an average of> 19 mg/L. In an extreme situation are the AP14 with 26,067 mg/L and AP10 with 25,899 mg/L.

Of the two samples collected in the Santa Luzia neighborhood, AP8, 45,779 mg/L and AP9, 36,065 mg/L nitrate were found in the neighborhood of> 40 mg/L. In the neighborhood of Nossa Senhora de Fátima, the average found average of> 22 mg/L. In the Chacareiro neighborhood the average content was> 11 mg/L.

After the high levels of N nitrate (NO3-) found in the sample points, it was decided to extend the sample to the other occupied districts of the urban area of Nova Mamoré.

Second Sample Group. According to table 2, the neighborhoods Planalto, Novo Horizonte, João Francisco Clímaco and Cidade Nova were part of this sample. The samples detected showed high levels of N nitrate (NO3-), above 10 mg/L, characteristic of waters with a high degree of contamination.

In the Planalto neighborhood, 100% of the samples showed high levels of N nitrate (NO3-), above 10 mg/L, with a mean of> 21 mg/L. The APs 21, 22, 23, 24 and 25 respectively were found to contain 28.466 mg/L, 22.079 mg/L, 23.780 mg/L, 20.332 mg/L and 15.198 mg/L nitrate.

In the Novo Horizonte neighborhood, unlike the other districts of the city, only 20% of the samples present levels> 10 mg/L. The others, 80% of the samples presented levels lower than 10 mg/L of nitrate.

In the João Francisco Clímaco neighborhood, 60% of the samples presented levels higher than 10 mg/L of nitrate. The average found was> 12 mg/L. However, there were marked differences such as AP 31, 19.665 mg/L and AP 34, with 2.166 mg/L nitrate.

In the Cidade Nova neighborhood, 80% of the samples present N nitrate (NO3-) levels higher than 10 mg/L. The average N nitrate (NO3-) content found was> 11 mg/L.

In the first analysis it can be affirmed that the groundwater used by the population of Nova Mamoré for human consumption and other utilities, are impacted with high levels of N nitrate (NO3-). 73% of the samples present levels> 10 mg/L of nitrate. These sites constitute urban areas of high environmental risk to human health, a public health issue. Only 17% presented levels <10 mg/L of nitrate. Only 7.5% of the samples are less than 3 mg/L of nitrate.

The high concentration of nitrate in urban groundwater in cities in the Brazilian Amazon puts the health of a large part of the population that supplies this type of water resources for human consumption.

Among the conditions that exacerbate the situation of water contamination by N nitrate (NO3-) in the urban

https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

area of Nova Mamoré is the inefficiency of the basic sanitation (water supply and sewage collection) of the municipality. The number of households with access to the general water network is still very low, only 10.88% of the households, while 83.91% of the households (residences) are supplied by wells or spring on the property and only 4.84% or spring off the property. The inefficiency of basic urban infrastructure is intrinsic to the quality of life of residents of any neighborhood in the city of Nova Mamoré.

Regarding sanitary sewage, the predominant type of sanitary sewage is the rudimentary septic tank with a percentage of 80.73%, followed by the septic tank with 9.02% and only 0.10% has access to the general sewage network or rainfall [22].

The proportion of households with adequate sanitation was only 1.13%, well below the proportion of the State of Rondônia (11.62%), while 49.08% was semi-adequate and 49.79% inadequate, thus indicating that the sanitation is still very precarious.

Deficiency in basic sanitation can lead to public health problems, as water pollution can lead to diseases such as: basilar dysentery, dengue fever, yellow fever, leptospirosis and others. The lack of sanitation in the municipality, still becomes more aggravating due to the fact that the great majority of the households (residences) of the municipality are supplied by wells or spring. Another implication of the lack of sanitation concerns environmental damage, such as flooding, silting up of watercourses (due to deforestation and occupation of the banks), disappearance of green areas, collapse of slopes, impairment of watercourses that have seen garbage dumps and sewage channels [22].

A study by Paraguassú-Chaves et al [14] in the region of the Brazil / Bolivia border had already found that in the first large pre-flood / flooding area of the Madeira River and its tributaries in 50% of samples, high levels of N nitrate (NO3-), above 10 mg/L, characteristic of waters with high degree of impaction. Water not suitable for human consumption. 40% had a content> 3 mg/L, at 50%> 10 mg/L, the total contamination of the aquifer becomes evident. After the flood / flooding of the area, the degree of contamination increased in a frightening way, where 100% of the samples detected high N nitrate (NO3-)> 10 mg/L contents. 80% of the wells and collection points with contents> 10 mg/L were detected. Extreme situation of contents were found as 156.74 mg/L; 70.08 mg/L; 67.36 mg/L; 63.27 mg/L and 56.67 mg/L nitrate. All characteristic of waters with high degree of impaction.

In other points of collection of water that did not have direct influence by the flood / flood the nitrate levels did not undergo significant variations. In this area in 30% of the samples were detected content of (NO3-) greater than 10mg/L. Water not suitable for human consumption. In 70% of the samples, a content higher than 3 mg/L was detected, which characterizes water with a high degree of impaction, although it is not close to the results found in the areas of situation I, an area impacted by flooding / flooding of the Madeira River. [14].

The precarious infrastructure conditions, the use of Amazonian well water and tubular wells without maintenance and close to the septic and black wells are conditioning and / or determinant for this scenario [14].

Table.1: Nitrate Concentration (NO3-) detected at sampling points of water collection in the First Sampling Group.

AMOSTRAL POINT	NEIGHBORHOOD	AMOSTRAL POINT	NEIGHBORHOOD
AP	**Downtown**	AP	**São José**
AP 1	42.298	AP 10	25.899
AP 2	41.335	AP 11	19.300
AP 3	35.145	AP 12	19.766
AP 4	24.011	AP 13	18.555
AP 5	23.086	AP 14	26.067
AP 6	16.441	AP 15	12.445
AP 7	12.123	AP 16	16.600
AP	**Santa Luzia**	**AP**	**N. Sra. de Fátima**
AP 8	45.779	AP 17	35.575
AP 9	36.065	AP 18	10.019
		AP	**Chacareiro**
		AP 19	12.080
		AP 20	10.119

https://dx.doi.org/10.22161/ijaers.6.1.14 ISSN: 2349-6495(P) | 2456-1908(O)

Table.2: Nitrate Concentration (NO3-) detected at sampling points of water collection in the Second Sampling Group.

AMOSTRAL POINT	NEIGHBORHOOD	AMOSTRAL POINT	NEIGHBORHOOD
AP	**Planalto**	**AP**	**J. Francisco Clímaco**
AP 21	28.466	AP 31	19.665
AP 22	22.079	AP 32	17.019
AP 23	23.780	AP 33	15.223
AP 24	20.332	AP 34	2.166
AP 25	15.198	AP 35	8.458
AP	**N. Horizonte**	**AP**	**Cidade Nova**
AP 26	13.655	AP 36	12.498
AP 27	4.788	AP 36	13.917
AP 28	0.332	AP 38	12.045
AP 29	3.336	AP 39	9.566
AP 30	2.145	AP 40	11.002

In Rondônia, Brazilian Amazonia, other researches have presented results that demonstrate elevated levels of nitrate in urban and rural groundwater. Lima [13] in his research in the Jaci-Paraná Free Aquifer, in zone 3 of the city of Porto Velho, found him partially contaminated by nitrate. In 68% of the water samples, contents higher than 3 mg/L were identified, which indicates alteration in the chemical composition of the water by anthropogenic activities. The sampling points, the shallow wells, used in this study, 100% have depth up to 12 meters [14]. In 33% of the water samples nitrate levels were detected above or very close to the limit of 10 mg/L, the maximum value allowed in Brazil for water intended for human consumption, according to Ordinance no. 518 of March 25, 2004 from the Ministry of Health.

Campos [23] in research in the municipality of Mirante da Serra in Rondônia found high levels of nitrate (NO3-) in the most densely populated urban areas. For Lima [13], it is important to consider that, even in low concentrations, the presence of nitrate in the water, besides indicating that the contamination is old in the environment, reveals the presence of organic matter associated with bacteria, viruses and parasites, alive or in some stages of decomposition. These agents cause various diseases, mainly acute diarrhea and, in the form of nitrate, is a carcinogenic indicator.

Excess nitrate ion in drinking water is worrisome because of its potential link to stomach cancer, but the research done is still unsatisfactory to clarify this relationship. Baird and Cann [24] state that published studies show that women who drank water from the public supply with a high level of nitrate (> 2.46 mg/L) are three times more likely to be diagnosed with breast cancer than the least exposed (<0.36 mg/L in drinking water).

Health hazards such as diarrheal diseases and gastroenteritis are commonly reported and recorded in the health care system of the counties surveyed. Attention is drawn to the studies of Alaburda & Nishihara [25] regarding the health concern of the population, especially the health of children and the elderly, as they are more susceptible to the development of methemoglobinemia due to exposure to high nitrate concentration and in adults the stomach cancers.

The research of Barata [15] in the urban groundwater of Nova Mamoré, the results presented a heterogeneous distribution, varying in the behavior of the contamination plume in which 37.5% of the samples presented levels <10 mg/L of Nitrate and 62.5% of the samples. samples presented levels> 10mg/L of Nitrate (NO3-) [15].

The highest levels of nitrate (NO3-) were present on the lateritic residual plateau, which covers a large part of the urban area of Nova Mamoré. These values are associated to the periods of occupation of the urban space considered older, since the central area of the urban center, called "Center", was the first to be occupied, as demonstrated. The oldest population density in the municipality is associated with Nitrate levels ranging from 21.51 mg/L to 45.77 mg/L, with a gradual decrease in the most recent occupation areas [15].

The extreme values of 42.0 and 45.8 mg/L were observed in the urban area of the oldest human occupation, as opposed to the minimum values of 0 and 2 mg/L, located outside the central area of the city and associated with with low population density.

Still based on the existing districts in New Mamore: Cidade Nova; Chacareiro; Novo Horizonte and Ambrósio, Nitrate levels (NO3-) were found below 9.70 mg/L and, therefore, below the maximum limit of 10 mg/L determined by Ministry of Health Ordinance No. 2,914 / 2011 [15].

Barata [15] analyzed the isoprobability of occurrence values above 10 mg/L, and found that the area with the highest occurrence of nitrate levels and with probability of occurrence in a percentage between 70 and 100% is that of the central urban center of Nova Mamoré , cut by BR-364, which acts as an agent facilitating the occupation

https://dx.doi.org/10.22161/ijaers.6.1.14 *ISSN: 2349-6495(P) | 2456-1908(O)*

and urban transformation of the city, the consequences of this urban concentration motivated by the BR, resulted in the contamination of the groundwater of the place studied.

The values of low probability of contamination, in general, range from 0 to 53% in areas farther from the central axis with urban influence. A transition band with a probability of up to 53% and greater than 72% of occurrence was observed, above 10 mg/L, which, in this case, is associated with the presence of drainage of the Ambrósio canal and the Olaria stream.

Figure 1 shows the neighborhoods where the samples were collected and Figure 2 shows the nitrate concentration (NO3-) map with a cut-off level> 10mg/L by Barata [15] confirming the high nitrate levels. Much of the population of Nova Mamoré is consuming water with a high degree of contamination, that is, water that is unfit for human consumption. An eminent public health problem.

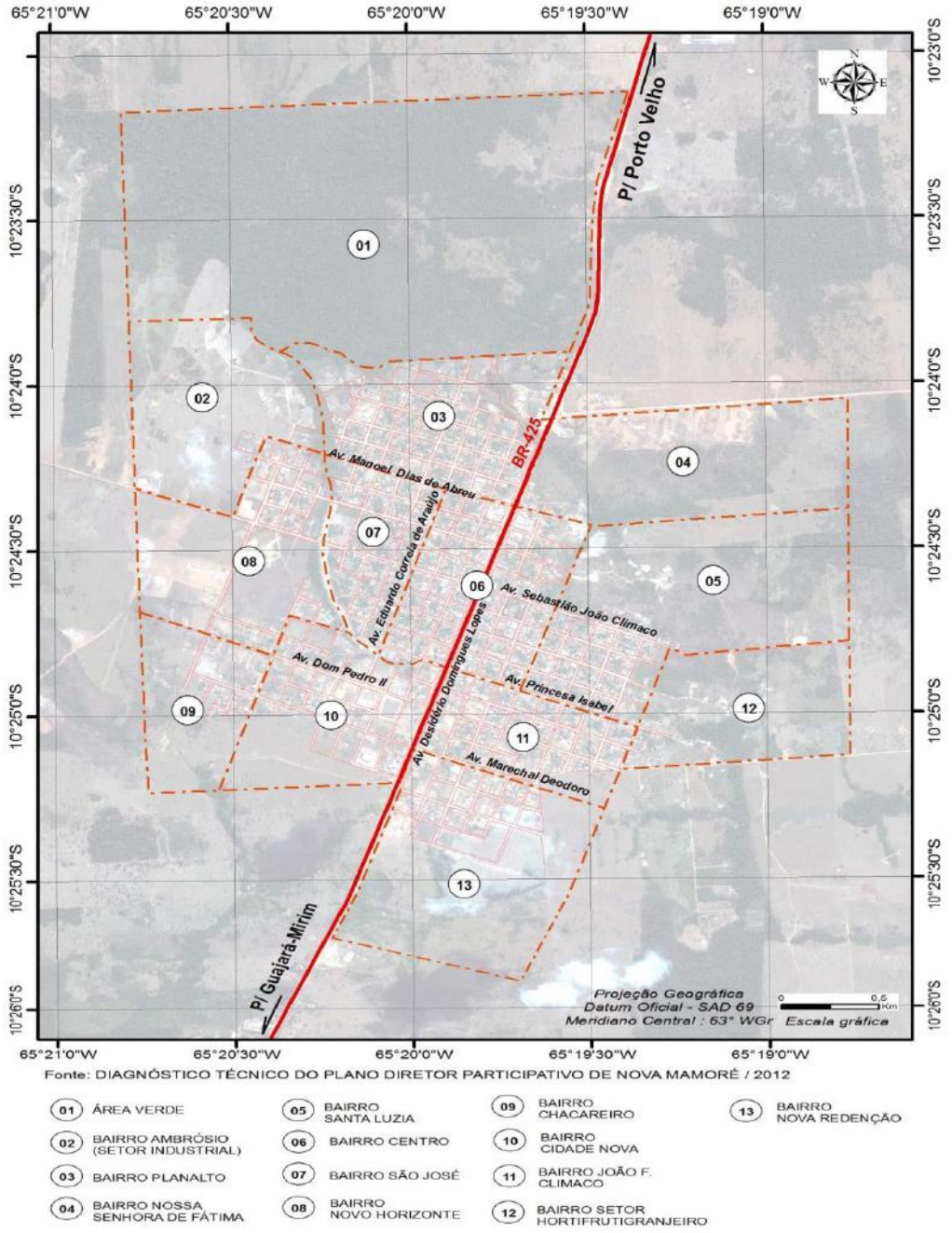

Fig.1: Map of the administrative division of the urban area of Nova Mamoré

https://dx.doi.org/10.22161/ijaers.6.1.14 *ISSN: 2349-6495(P) | 2456-1908(O)*

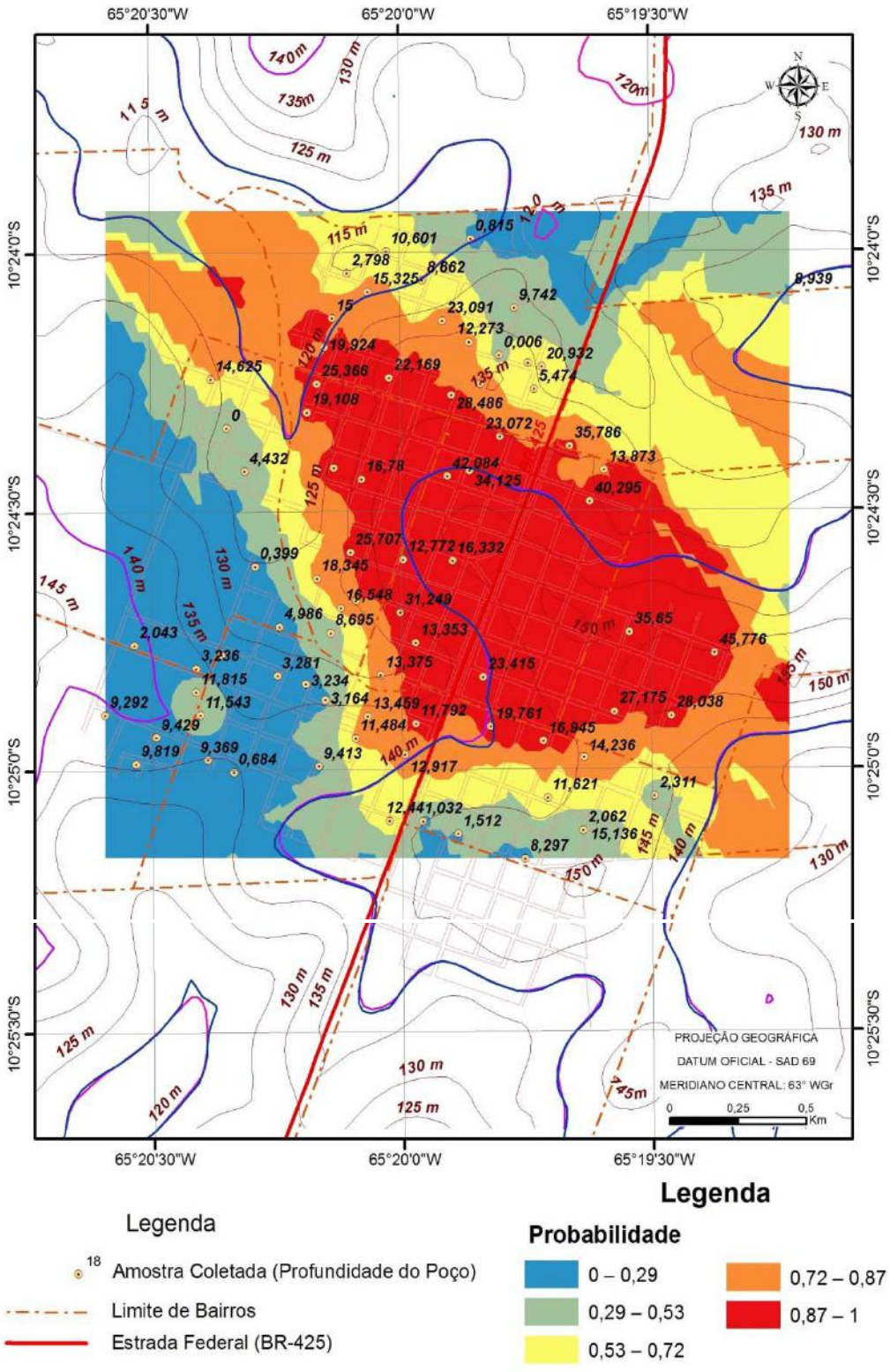

Fig.2: Map of nitrate concentration (NO3-) with cut level> 10mg/l

IV. CONCLUSIONS

The urban groundwater used by the population of Nova Mamoré for human consumption and other utilities are impacted by high levels of N nitrate (NO3-).

Seventy - three percent (73%) of the samples presented levels> 10 mg/L of nitrate. These sites constitute urban areas of high environmental risk to human health, a public

https://dx.doi.org/10.22161/ijaers.6.1.14 *ISSN: 2349-6495(P) | 2456-1908(O)*

health issue. Only 7.5% of the samples are less than 3 mg/L of nitrate.

The high concentration of nitrate in urban groundwater in cities in the Brazilian Amazon puts at risk the health of a large part of the population that supplies this type of water resources for human consumption. Among the conditions that exacerbate the N nitrate (NO3-) contamination in the urban area of Nova Mamoré, there is the inefficiency of basic sanitation (water supply and sanitary sewage collection, predominance of rudimentary and septic fossa in a precarious state).

REFERENCES

[1] VARNIER, C. L.; HIRATA, R. (2002). Contamination of groundwater by nitrate in the Tietê ecological park. Journal of the Brazilian Association of Underground Waters, v. 16, p. 77-82, 97-104.

[2] RONDÔNIA - CAERD. COMPANY OF WATER AND SEWERS OF RONDÔNIA. (2006). Technical operational diagnosis of water supply and sewage systems: Basic Sanitation Program of the State of Rondônia. Porto Velho: Management of Projects and Works, 298 p.

[3] CAMPOS, J. C. V. (2003). The problem of underground water resources in the Amazon in the view of the Geological Service of Brazil. In: I SYMPOSIUM OF HYDROGEOLOGY OF SOUTHEAST, Rio de Janeiro: p. 133-141.

[4] BRAZIL. Ministry of Health. (2011). Ordinance MS No. 2,914 / 2011. Brasília. Ministry of Health, 32 p.

[5] SILVA, L.C.M; BROTTO, M.E. (s / d). Nitrate in Water: Occurrence and Consequences. School of Chemistry, Oswaldo Cruz College. Sao Paulo.

[6] CAMPOS, T. DE S.; ROHLFS, D.B. (2011). Evaluation of nitrate values in groundwater and its correlation with anthropic activities in the city of Águas Lindas de Goiás, Goiânia. PUC. Available at: <http://www.cpgls.ucg.br/arquivosUpload/1/File/.../ SAUDE / 86.pdf.>. Accessed on: 02 Apr 2018.

[7] MELO JUNIOR, H. R. et.al. (2006). Evaluation of the Quality of Groundwater in an Urban Zone of the Brazilian Amazon: Case study of the Eletronorte neighborhood, Porto Velho (RO). In: BRAZILIAN UNDERGROUND WATER CONGRESS, 14, 2006, Curitiba: Anais. Curitiba: ABAS, p. 1-20.

[8] BARBOSA, C.F. (2005). Hydrogeochemistry and nitrate contamination in groundwater in the Piranema neighborhood, Seropédica - RJ. Dissertation (Master degree) - State University of Campinas, Campinas. Available at: <http://www.bibliotecadigital.unicamp.br>. Accessed on: 21 Sept. 2018.

[9] FOSTER, S.; VENTURA, M.; HIRATA, R.C.A. (1993). Groundwater Pollution. São Paulo: Manual Series. Geological Institute. Secretariat of the Environment. 53 p.

[10] DANIEL, M.H., B. (2008). Characterization of nitrate profile in water for human consumption in Natal - RN. Monograph (Specialization) - University of Brasília, Federal District.

[11] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; UCHOA, M.R.; BARATA, C. S.; SILVEIRA, E.G.; DANTAS, L. R. M. (2015). Possible Nitrate Concentration (NO3-) in the Urban Area of the Rondônia Border. Debate in action: scientific discussion, v. 1, p. 70-79.

[12] PARAGUASSÚ-CHAVES, C.A; CAVALCANTE, F.R.C; DANTAS, L.R.M; SOUSA, A.A; CLEARS, P.C.G; SILVA, I.R.R.P; NEVES, J.T; CALDERARO, I.F.N, OLIVEIRA, P.T.C; ALMEIDA, F.M. (2018). Groundwater quality: Study of the Nitrate (NO3-) concentration in the Urban Area of the Brazil / Bolivia Border. International Journal of Advanced Engineering Research and Science (IJAERS) [Vol-5, Issue-10, Oct-2018]

[13] LIMA, M.L.A. (2008). Groundwater potentially impacted by nitrate (NO3-) in the urban area of the city of Porto Velho; A study of health geography. (Dissertation). Master's program in geography. Federal University of Rondônia. Porto Velho.

[14] PARAGUASSÚ-CHAVES, C.A; BARATA, C.S; SILVA FILHO, E.P; ALMEIDA, F. M; DANTAS, L.R.M. (2018). Mapping of Nitrate Contamination (NO3-) in an Urban Area on the Brazil / Bolivia Border. Debate in Action: scientific discussion. Preliminary publication.

[15] BARATA, C.S. (2016). Mapping of the contamination by nitrate (NO3 -) in shallow wells in the area of the headquarters of the municipality of Nova Mamoré - Rondônia. (Dissertation). Master's program in geography. Federal University of Rondônia. Porto Velho.

[16] IBGE. BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS. (2014). http://www.cidades.ibge.gov.br/v3/cidades/home-cidades

[17] RONDÔNIA - CAERD. COMPANY OF WATER AND SEWERS OF RONDÔNIA. (2014). Technical operational diagnosis of water supply and sewage systems: Basic Sanitation Program of the State of Rondônia. Porto Velho: Management of Projects and Works, 298 p.

https://dx.doi.org/10.22161/ijaers.6.1.14 *ISSN: 2349-6495(P) | 2456-1908(O)*

[18] RONDÔNIA - CAERD. COMPANY OF WATER AND SEWERS OF RONDÔNIA. (2014). Environmental Monitoring Report of Nova Mamoré-RO. Porto Velho: p.5

[19] RONDÔNIA - CAERD. COMPANY OF WATER AND SEWERS OF RONDÔNIA. (2014). EBITDA from January to December 2014. Superintendency of Planning. Porto Velho.

[20] APHA - AMERICAN PUBLIC HEALTH ASSOCIATION (APHA). (1998). Standard Methods for the Examination of water and wastewater. 17 ed. Washington: p. 475-93.

[21] CETESB. (1987). National Collection Guide, preservation of water samples.

[22] NEW MAMORÉ. (2012). Diagnosis of the Participative Master Plan of Nova Mamoré. New Mamore.

[23] CAMPOS, J.C.V. (1999). Contamination of groundwater in the city of Mirante da Serra (RO). Porto Velho: Geological Survey of Brazil, p. 1-11.

[24] BAIRD, C.; CANN, M. (2011). Environmental Chemistry. 4. ed. Porto Alegre: Bookman.

[25] ALABURDA, J; NISHIHARA, L. (1998). Presence of Nitrogen Compounds in Well Waters. Journal of Public Health, Rio de Janeiro, v. 32, n. 2, p. 160-5, apr.